09/486264
430 Rec'd PCT/PTO 25 FEB 2000

WO99/10613

PCT/CH98/00346

Reinforcing Device for Supporting Structures

The present invention relates to a reinforcing device according to the preamble of Claim 1 as well as a method for reinforcing beams according to the preamble of Claim 11.

When rehabilitating supporting structures in existing buildings, the problem often arises that the supporting structure is to be adapted for new load cases that exceed the former dimensions. In order to avoid replacing the supporting structure completely in such cases, methods and devices for reinforcing such existing supporting structures have been found. Such supporting structures can be walls of conventional design made of brick, reinforced concrete walls or beams, or beams made of wood, plastic, or steel for example.

Reinforcement of such supporting structures with steel plates added later has been known for a long time. The steel plates, in other words strips of sheet steel or steel panels, are glued to one or both sides of the supporting structure, preferably on the side of the supporting structure subjected to tension. The advantage of this method consists in the fact that it can be implemented relatively quickly but imposes strict requirements on the adhesive, in other words the preparation of the parts and the performance of the adhesion process must take place under precisely defined conditions to achieve the desired effect. Problems arise with this method especially in the area of corrosion, in other words when supporting structures are to be reinforced in this manner in the open, such as bridge beams for example. Because of the relatively high weight and the production of such steel panels, the maximum length that can be used is limited. Likewise, for reasons of space, installation in closed spaces can be problematic when the rigid steel panels cannot be transported into the space in question. In addition, the steel plates must be pressed against the supporting structure to be reinforced until the adhesive sets in "overhead" applications, which also means high cost.

It is known from FR 2 590 608 to use tensioning means in the form of strips of metal or fiber-reinforced plastic with anchors at the ends. In this embodiment however there is no flush connection between the tensioning means and the supporting structure but a connection with the supporting structure is provided only in the two end anchoring points of the tensioning means. Clamping means of this kind are conventionally included when planning the supporting structure since retrofitting is practically impossible or can be done only at very high cost,

since corresponding channels in the supports must be prepared for the clamping means.

Recently, carbon panels (CFK panels) are glued to the tensioned sides of the supporting structure and thus the carrying capacity of such structures is subsequently improved by increasing the supporting resistance and ductility. Advantageously, the simple and economical application of such panels which have a higher strength than steel panels with a far smaller weight are simpler to install. The corrosion resistance is also better so that such reinforcements are also suitable for reinforcing supporting structures in the open. However, the end anchoring of the panels in particular has proven to be problematical. The danger of the panels coming loose is particularly great in this area and there is a problem of introducing the force from the end of the panel into the beam.

A solution is this regard is known from WO96/21785 in which a bore that runs at an obtuse angle or a wedge-shaped recess is made in the beam in which the ends of the CFK panels are inserted and pressed against the beam, possibly by clamps, loops, plates, etc. This results in an improvement in the loosening behavior and an improved initiation of the force from the beam into the panel. However, such CFK panels are glued without pretensioning, in other words flexibly to the beam. As a result however, much of the reinforcing potential of these panels is not utilized since panels begin to provide support only after they exceed the basic load, in other words under stress from the useful load itself.

In order to utilize the panels better, the idea has arisen of gluing them pretensioned to the beam. One known solution in this regard provides that short steel plates are glued to the ends of the CFK panels on both sides and the steel plates are then pulled apart and the CFK panels are pretensioned and this pretensioned arrangement is glued to the beam to be reinforced. After the glue dries, the panels are pressed at the ends against the beams by plates, loops, etc. and the ends are then cut off with the steel plates. This method however is very expensive and cannot be used in all applications. The method of anchoring the panel ends described above is not suitable however for pretensioning at building sites.

Hence, the goal of the present invention is to provide a CFK reinforcing panel in which the introduction of the force from the beam into the ends takes place in such fashion that separation becomes practically impossible and which is also suitable for pretensioning.

This goal is achieved according to the invention by a CFK panel with the features of Claim 1 or by the method according to Claim 11. Preferred embodiments of the invention follow from dependent Claims 2 to 10 and 12 to 14.

By splitting the ends of a CFK panel into at least two and preferably three or more end strips, the surface for connection to an end element is increased considerably. As a result, there is a good initiation of the force into the ends of the CFK panel which can also be pretensioned in simple fashion by such an end element. The end element in block form can be either inserted into a depression in the beam or in the preferred embodiment, with a wedge-shaped split with a flat or rough bottom, can also be glued and/or doweled or simply bolted flush to the beam. It is this embodiment that is preferably suited for pretensioning which preferably takes place directly through the beam part. For example, this can be done by tensioning against a fitting inserted into the beam.

The splitting of the ends of the CFK panels can preferably take the form either of strips on top of one another or strips that are side-by-side, or in a combination of these two versions.

The ends of the CFK panels can advantageously be split at the building site itself to the required length and dimensions. This makes this system highly universal for the reinforcement of practically any beam and can be employed with or without pretensioning.

One embodiment of the invention is described in greater detail below with reference to the figures in the enclosed drawing.

Figure 1 shows a cross section through a beam with a CFK panel according to the invention attached to the underside;

Figure 2 shows a cross section through the head part of the CFK panel in Figure 1;

Figure 3 shows a cross section through the end of a CFK panel according to Figures 1 and 2;

Figure 4 shows a cross section through a beam with an additional CFK panel according to the invention mounted on the underside;

Figure 5 shows a cross section through the head part of the CFK panel according to Figure 4;

Figure 6 shows a schematic cross section through an alternative head part of a CFK panel according to the invention;

Figure 7 is a schematic cross section through an additional alternative head part of a CFK panel according to the invention;

Figure 8 is a top view of another alternative embodiment of the head part of a CFK panel.

Figure 1 shows a cross section through a beam 1 to be reinforced. The ends of the CFK panel 2 used for this purpose are inserted according to the invention in elements, in this case anchor heads 3 and 4. Anchor heads 3, 4 can be inserted into milled or pointed recesses of beam 1 as shown in this figure. CFK panel 2 is connected with beam 1 over part or all of the area by means of a layer of adhesive 5 and the anchor heads 3, 4 are glued to it as well. In addition, anchor heads 3, 4 can be connected with the beam by a transverse clamping device 6, shown here simply schematically, resulting in an improved direction of the force through anchor heads 3, 4 from CFK panel 2 into beam 1. This transverse clamping device 6 can be for example a threaded rod or dowel guided through beam 1 and anchor heads 3, 4.

The reinforcing device composed of CFK panel 2 and anchor heads 3, 4 can also be simply pretensioned as shown schematically on the right-hand side of Figure 1. For this purpose, for example, an angular fitting 7 can be attached to the underside 1 of the beam, said fitting being gripped by a tension rod 8 connected at one of its ends by anchor head 4. It is advantageous that both anchor heads 3, 4 must be provided with such a tensioning device for pretensioning. The clamping device is mounted before gluing and can be removed again after the adhesive cures between CFK panel 2 or anchor heads 3, 4 and beam 1.

Figure 2 shows a cross section through one of anchor heads 2. In anchor head 3 in the form of a parallelepiped, preferably three guide or retaining slots 9 are provided one above the other which can accept the end of CFK panel 2 divided into three tabs 2' as shown in Figure 3.

Retaining slots 9 are spread upward and downward wedgewise and have transverse bores 10. These bores 10 provide additional anchoring points for the adhesive that connects strips 2' of CFK panel 2 with retaining slots 9. In this way, the introduction of tensile forces from beam 1 through anchor head 3 into CFK panel 2 is additionally improved. The great advantage however lies in splitting the end of panel 2 into strips 2'. This splitting is preferably performed in the fiber direction of the panels and advantageously results in an increase in gluing area without the strength properties of the CFK panel 2 being adversely affected.

In the present example with three strips 2', the gluing area is increased six times by comparison with a conventional panel that is simply glued at its end to the beam and is increased three times over the known solution with a wedge-shaped recess in the beam and adhesion bridges.

In order in the outlet area of anchor head 3 of CFK panel 2 to prevent bending or tearing of the anchor head by transverse forces that result from the wedge-shaped or arcuate arrangement of retaining slots 9, a transverse reinforcement 11 is advantageously provided which is only indicated schematically in Figure 2. For example, this transverse reinforcement 11 can be provided by threaded rods guided through matching bores in anchor head 3 and tightened by nuts. Thus, any shear stress peaks in the outlet area of anchor head 3 are subject to overpressure and higher shear stresses are permitted in this zone.

In addition, a threaded bore 12 is provided in anchor head 3 for example into which bore a pretensioning device can be screwed as shown schematically in Figure 1.

Figure 3 shows, as already mentioned, one end of the CFK panel 2 with the end of the panel split into three strips 2'. The CFK panel can be split by conventional means following cutting to length, to the desired length and the desired number of equally thick strips 2', for example by means of a plane or knife. It is advantageous in this regard that relatively low requirements are imposed on the quality of the splitting; the important aspect is the division into the correct number of strips 2' to achieve the increase in area for the connection to the anchor head 3.

Figure 4 shows a cross section through a beam 1 with a reinforcing device according to the invention mounted on the underside (tension side), consisting of a CFK panel 2 with anchor heads 12, 13 attached to the ends. Anchor heads 12 and 13 are so designed that the CFK panel 2 emerges practically at the level of adhesive layer 5 from anchor heads 12, 13 and the latter therefore must not be depressed in the underside of beam 1 but must also be glued flush to the underside for example. Of course, the transverse tensioning devices 6 shown in Figure 1 can also be mounted here to produce a higher pressure and thus a higher tensile strength of the connection between anchor heads 12, 13 and the underside of the beam. Likewise, these anchor heads 12, 13, like the embodiment already described above, can be pretensioned simply.

Figure 5 shows a cross section through an anchor head 12 and the corresponding arrangement of the holding slots 9. The bottom slot 9' is parallel to the outside wall 12' of anchor head 12, resting on beam 1, and the other slots 9 are located at an acute angle pointing outward in the form of a fan. This arrangement offers the same advantages as already described as a result of the increase in the gluing surface of the CFK panel 2 and also allows the flush application of anchor heads 12, 13 as well without additional recesses in beam 1. These anchor heads 12, 13 as well have transverse reinforcing means 11, as shown schematically in Figure 2, to avoid bending or tearing of anchor heads 12, 13 in the area where the CFK panel 2 emerges.

As material for anchor heads 3, 4 and 12, 13, metal is suitable which exhibits high strength, ease of machining, and good force initiation properties, as is plastic, especially when corrosion is expected to be high.

Figure 6 is a schematic view of another embodiment of the reinforcing device according to the invention. The end of CFK panel 2 is split here into two superimposed strips 2' which come to rest on the outside of a wedge-shaped anchor head 14. There they can be connected to the surface of anchor head 14 by gluing.

In another embodiment according to the invention, the split strips 2' at the end of CFK panel 2 are held in an anchor head composed of plates 15 located parallel one on top of the other as shown in a lengthwise section in Figure 7. Here a screw connection 16 can be advantageously employed to press plate 15 and strips 2' against one another.

Figure 8 is a top view of another embodiment of the end of CFK panel 2. Here the strips 2' are not shown one on top of the other but are located laterally side by side. Here again, the split is preferably made in the fiber direction of the CFK panel 2.

The reinforcing devices according to the invention are especially suited for rehabilitating existing concrete beam structures, such as ceilings or bridge beams. However, they can also be used for all known applications of conventional CFK panels, for example masonry and wooden supporting structures. The ease with which they can be pretensioned permits a greater utilization of the strength properties of the CFK panels than in known methods. In addition, pretensioning means that on the tension side of an existing supporting element, pre-pressing takes place that is advantageous for example in the case of bridge beams.